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UNDERSEA EXPLORATION

by

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UNDERSEA EXPLORATION

COMPETITION in the exploration of outer space may soon have a counterpart in the inner depths of the oceans, where rivalry among nations to unlock secrets of the sea is rapidly growing. President Kennedy asked Congress on March 29 to agree to a doubling of last year's budget for oceanographic research and thus to provide nearly $100 million for undersea exploration in the fiscal year 1962. The Senate Commerce Committee on June 20 reported a bill, similar to one passed by the Senate in June 1960, which would authorize a 10-year oceanographic program costing $700 millon. The Navy, prompted by intelligence reports that the Russians are doing three or four times as much oceanographic research as the United States, proposed a 10-year program on May 29 that would cost more than $900 million.

A note of urgency has been injected into the drive for stepped-up investment of money and brains in study of the oceans. "Knowledge of the oceans," the President said last spring, "is more than a matter of curiosity. Our very survival may hinge upon it." This warning echoed the conclusions of three scientific bodies which recently have surveyed the needs and prospects in ocean research. It reflected also the conclusions of three congressional committees which have conducted hearings on the subject in the past two years.[1] Chairman Warren G. Magnuson (D Wash.) of the Senate Commerce Committee, author of the bill now pending in the Senate, believes that "The lag in marine research can be as fatal to our welfare and security as failure to match Russia in space research and development." [2]

The committee report on the pending bill noted that a number of other nations are engaged in a national oceanographic effort and that Soviet Russia outstrips the free

[1] Senate Commerce Committee, House Committee on Science and Astronautics, and Subcommittee on Oceanography of House Committee on Merchant Marine and Fisheries.

[2] Address, Franklin Institute, Feb. 17, 1960.

world in this respect. "To deny the principal competitor of the free world this leadership . . . is a duty and responsibility of the democracy which potentially is most capable of unlocking the ocean's secrets—the United States," the report declared. ". . . At least 10 years of vigorous, continued, amply supported and systematic research will be required." Virtually all of the many scientists who testified before the Senate committee concurred in a warning by Sumner Pike, former member of the Atomic Energy Commission and now a member of the Committee on Oceanography of the National Academy of Sciences. Pike had said: "Another nation caught us practically unawares upstairs; for heaven's sake, don't let the same thing happen to us down cellar." [3]

Like the space beyond the globe, the depths of the oceans constitute a mysterious realm. Key instruments for exploring that realm are only now being developed. The need is pressing to refine and develop those instruments, to build more laboratories afloat and ashore, and to train more oceanographers. Knowledge to be gained from the inner depths will have important bearing on national defense, on the design of undersea vessels and weapons, on forecasting and possibly influencing weather and climate, on developing new sources of food, fuels and minerals, on methods of preventing radioactive contamination, and on medical research. But even if practical rewards were not in view, scientists would be drawn to the ocean depths because they contain answers to many mysteries of the earth's origin.

Calls for Expansion of Oceanic Research

Pending proposals for increased federal support of oceanic research are based mainly on a series of 12 reports issued in 1959 and 1960, under the over-all title *Oceanography 1960 to 1970*, by the Committee on Oceanography of the National Academy of Sciences. This committee of non-governmental scientists, known as NASCO, was formed in 1957 at the request of several federal agencies concerned with the marine sciences.[4] NASCO found that "progress in the marine sciences in the United States has been slow," particularly in view of the "essential and exciting infor-

[3] Senate Commerce Committee, report on "Marine Sciences and Research Act," June 7, 1960, p. 2.

[4] Office of Naval Research, Fish and Wildlife Service of the Department of the Interior, Atomic Energy Commission, National Science Foundation.

mation yet to be obtained by probing the vast and dark but penetrable depths of water which cover . . . [71 per cent] of the earth's surface."

NASCO recommended a 10-year program to cost $651 million, not including expenditures for military aspects of oceanography or for certain international projects. "Action on a scale appreciably less . . .," the committee said, "will jeopardize the position of oceanography in the United States relative to the position of the science in other major nations, thereby accentuating serious military and political dangers and placing the nation at a disadvantage in the future use of the resources of the sea."

The Federal Council for Science and Technology, created by executive order in May 1959 to coordinate government scientific programs, singled out oceanography as a neglected field and established an Interagency Committee on Oceanography made up of high-ranking officials.[5] The committee reviewed the NASCO reports and, while generally supporting their recommendations, raised the estimate of minimal outlays for the 10-year period to $1 billion—"a modest goal when the level of our present knowledge is considered in relation to our needs." [6]

The budget for oceanography recommended by President Kennedy for the fiscal year that began July 1 would divide $97.5 million among seven government agencies. The bulk of the fund would be used for research ($40 million) and ship construction ($37 million). The total sought compares with $55 million expended in the fiscal year 1961, $46 million in fiscal 1960, and $23.6 million in fiscal 1959. The President said he was not thinking in terms of a program limited to a specified number of years; approval of the expenditures he proposed would constitute "the first step in a continuing effort to acquire and apply the information about a part of our world that will ultimately determine conditions of life in the rest of the world."

Reasons for substantially expanding oceanographic research are not hard to find. Of immediate concern is the

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[5] Agencies represented include the Departments of Commerce, Defense, Health-Education-Welfare, and Interior, the National Science Foundation, and the Atomic Energy Commission.

[6] James H. Wakelin, Jr., Assistant Secretary of the Navy and chairman of the Interagency Committee on Oceanography, testimony before House Merchant Marine Subcommittee on Oceanography, May 17, 1960.

need for better understanding of the medium in which major instruments of national defense operate. Oceanography lies at the heart of the Navy's research and development program, for almost anything that can be learned about the sea has application to the design and operation of ships and ship equipment, navigation, and military planning. Advances in submarine design and operational capacity have made it all the more important that the Navy's knowledge of the oceans extend farther down than it has in the past.

Urgent Military Need for Study of the Deep

Experts told the congressional committees considering the subject that the military uses of oceanic research exceed those of interplanetary exploration. The first NASCO report stated:

> From the point of view of military operations there is no comparison between the urgencies of the problems of the oceans and those of outer space. The submarine armed with long-range missiles is probably the most potent weapon system threatening our security today. . . .
>
> The problems involved in military operations in the sea are enormous. We will not be able to navigate under the oceans with adequate precision until our knowledge is greatly expanded. Nor will we be able to detect submerged submarines efficiently unless we learn far more about the ocean depths than we now know.[7]

Rear Adm. E. C. Stephan, Hydrographer of the Navy, told a House Appropriations subcommittee on March 14 that "Despite the fact we have been in this business for 130 years, our knowledge is not very good even as to precise knowledge of the bottom of the ocean." A major lag is in the development of modern instrumentation for oceanography. "We are still using instruments that [are] practically of the 19th century."

Much is known about ocean currents on or near the surface, but little about the course and speed of those at greater depths where the undersea craft of the future will operate. The topography of the ocean bottom is known mostly in its shallower reaches. What little has been explored of the deeper floor shows it to be as variegated as land surfaces and even more dramatic in the way of peaks, valleys and rugged crevices.

Communication within the ocean is complicated by a

[7] The Navy's Project Artemis, which involves a midocean laboratory on a tower near Bermuda and a 17,000-ton tanker capable of lowering an enormous sound generator into the sea, aims to develop a system of long-range submarine detection.

myriad of fluctuating influences. A big difficulty is to find how to counteract interference with acoustic signals caused by congregations of noise-making creatures of the sea. Studies of marine biology are directed to means of controlling organisms that attack ship bottoms, cables and other undersea equipment, and to protection of underwater swimmers from attack by poisonous or carnivorous fish. Studies of the dolphin's extraordinary ability to swim at great speed without ruffling the water and to dodge obstructions are leading to improvements in the design of surface and underwater vessels.

Growing Need for Sea's Manifold Resources

The oceans offer the largest single field for future expansion of food and mineral supplies. The continental shelves —the sloping and relatively shallow sea bottoms that cover 12 million square miles between the shores and the abyss— are believed to contain 30 million cubic miles of oil-bearing sediments. It has been estimated that the continental shelves of the United States alone could, under present production practices, be made to yield 20 billion barrels of crude oil and 150 billion cubic feet of natural gas. The deeper floors of the ocean are known to contain a wealth of minerals, accumulated over the vast reaches of time by washings from the land. Manganese, cobalt, nickel and copper have been found recently in sediment at ocean bottoms, and there may be other lodes not yet discovered.

President Kennedy pointed out on March 29 that within 20 years the rapidly growing population of the United States will require a million tons of seafood beyond that now harvested; and other countries will have even greater need to tap this source of animal protein. More study of the environment and habits of sea life is needed for fuller exploitation of the oceanic food supply. A special study prepared for a congressional committee last year said:

> Information is presently lacking on the abundance and availability of fishery stocks, rhythmic season changes and sporadic fluctuations. With such information, fishing could be less hunting and more cultivation. . . . [Research] might go far toward eliminating the changes in abundance . . . which make the fishing industry so uncertain. . . . Modern technology affords opportunities now as never before to study fish and the process of fishing and thus to reduce the elements of luck and lore.[8]

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[8] House Committee on Science and Astronautics, *Ocean Sciences and National Security* (July 1, 1960), pp. 47-48.

Full exploitation of resources of the ocean bottoms may not depend on science alone. It probably will require also the negotiation of international agreements setting forth rules for staking out national claims and settling differences over who is entitled to what. Rival claims to fishing rights away from coastal waters have long been a source of bickering between nations. It may be assumed that ill feeling of this kind would be magnified if one country's fishing vessels were to help themselves to the product of a cultivation project carried on by another country. Unregulated exploitation of mineral and fuel resources of the ocean bottoms might produce even more serious contention.

Role in Control of Climate and in Medicine

Columbus O'Donnell Iselin of the Woods Hole Oceanographic Institution in Massachusetts, a member of the National Academy of Sciences Committee on Oceanography, has said that "The first benefit that . . . we will receive [from oceanic research] . . . is more reliable and longer-range weather forecasting."[9] Climate and weather are known to be related to interactions between the atmosphere and the ocean through the process by which the ocean absorbs the energy of the sun and gives back heat and moisture to the atmosphere. Salt and other particles entering the atmosphere from the sea become nuclei for condensation and thus play a part in cloud formation and precipitation. The sheer size of the oceans, covering more than two-thirds of the globe, gives them a major role in weather-making and in causing periodic shifts of climate. But there have been few measurements of the amount and rate of solar radiation at sea.

Only recently has it been realized that the deeper ocean currents, moving vertically and therefore altering the temperature of the higher waters and the surface atmosphere, help to create the conditions which produce precipitation and storms. Climatologists do not yet fully understand the mechanism by which ocean waters move up and down; they do not know whether the upsurging currents move continuously or intermittently. It is not yet possible to predict the timing and intensity of underwater earthquakes, which cause tidal waves to move rapidly over great distances and engulf coastal areas thousands of miles away.

[9] Testimony, House Merchant Marine Subcommittee on Oceanography, May 20, 1960.

If man could learn how to divert an ocean current, a form of man-made weather might be produced. It has been suggested that setting off a nuclear charge on the ocean floor might cause an upwelling of warm water that would modify the climate of shore areas or cause warm moist air to rise and sweep inland to bring about precipitation on arid lands. New knowledge of the ocean's weather-making function may give an answer to the troubling question of the ultimate effect on climate of the unprecedented release of carbon dioxide into the atmosphere since advent of the machine age. It may determine whether, or how soon, the earth is headed for another ice age.

Need for additional knowledge of ocean currents has been raised by use of the sea as a dump for radioactive wastes. Although only low-level wastes in sealed containers are dropped at sea, increasing industrial and military uses of nuclear power make it imperative to learn more about the circulation and mixing processes of the waters in areas where these wastes are deposited.

Oceanography offers promising possibilities to the medical researcher. A member of NASCO who is a zoologist recently pointed to three areas of oceanic research of importance to medical science: study of medically useful substances extracted from marine life, of toxins released in the sea, and of physical mechanisms, including parasitism, among sea organisms. "Because they represent the greatest diversity from simple to complex and . . . show myriad variations . . . marine animals provide essential information in many physiological studies." [10] Perhaps most important, studies of the embryo of marine invertebrates might throw light on factors controlling cell division, thus contributing to medical understanding of the nature of cancer.

Advances in Undersea Exploration

ALTHOUGH scattered studies of the oceans and of marine life were made in ancient times, modern oceanography got its start only a little more than a century ago, when accurate instruments for recording phenomena of the sea and

[10] Dixy Lee Ray, testimony, Senate Commerce Committee, March 16, 1961.

the atmosphere came into widespread shipboard use.[11] The first intensive study of ocean currents, winds and storm patterns was made by an American naval officer, Matthew Fontaine Maury, who reviewed information on winds and surface currents gathered from ship logs. Use of Maury's sailing charts substantially reduced the time required for passage along many ocean trade routes and thus effected large savings for shipowners. Maury's work on *The Physical Geography of the Sea*, published in 1855, treated the sea for the first time as a distinct branch of science and is recognized today as the first textbook of modern oceanography.[12]

Early Investigations of Phenomena of the Sea

Another pioneer, the British scientist Edward Forbes, made extensive investigations of the living organisms of the sea. Forbes eventually became leader of a new school of marine biologists, centered during the 1850s in the universities of Scotland. He was the first to observe the relationship of the chemistry, physics and bottom topography of the sea to the nature of marine plants and animals.[13] The first deep sea sounding was taken in 1840 by Sir James Clark Ross on a voyage to the Antarctic; he dropped a weighted hemp line to a depth of nearly 2,000 fathoms (about two miles).[14]

A great step forward in oceanographic research was taken in 1872 when the *Challenger*, a converted British navy vessel equipped with a biological and a chemical laboratory, put to sea on a scientific expedition which was to last 3½ years. This voyage, which covered 69,000 miles, still holds the record as the longest continuous scientific expedition. Stopping at 362 fixed stations on the high seas, the *Challenger* scooped up samples of ocean bottom and living organisms and took soundings that gave a rough idea of the depths and contours of the ocean floor.[15]

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[11] Forerunners of the modern oceanographer include Aristotle, who studied marine life; Benjamin Franklin, who published a chart of the Gulf Stream in 1786; and Capt. James Cook, who gathered oceanographic information during voyages of exploration in 1768-69.

[12] H. A. Marmer, "Matthew Fontaine Maury," *Dictionary of American Biography* (Vol. XII, 1933), p. 429.

[13] Like many scientists of his day, Forbes was under the mistaken impression that life did not exist more than 1,800 feet below the surface of the sea. His theory of an "azoic zone" in the ocean collapsed in 1860 when mollusks were found attached to a broken cable hauled up from a depth of 7,200 feet in the Mediterranean.

[14] Magellan made the first attempt at deep sea sounding in the Pacific in 1521. His rope, lowered to 1,200 feet, failed to touch bottom.

[15] The *Challenger* moved under sail but had auxiliary steam power for operating equipment and maintaining stability on station.

> When the expedition left, . . . knowledge of the deep sea was almost a total blank. When it returned home and all the subsequent reports were published, the ocean was still a largely unknown wilderness, but its gross measurements had at last been taken. New and often bizarre-looking animals were found by the hundreds. Naturalists eventually identified 4,717 new species and 715 new genera from the specimens brought back.[16]

It took 19 years to assemble and analyze the data and samples obtained by the *Challenger*. Eventually 50 volumes of findings were published, providing a solid base on which the rising science of oceanography could build. The *Challenger's* adventure inspired broad new interest in oceanographic research. In the ensuing years most of the great sea powers sponsored expeditions to extend further man's knowledge of the ocean depths.

Improvement of Equipment for Deep Sea Study

Progress in oceanography has been paced by the advance of technology for deep sea exploration. Major tools for studying the physical properties of the oceans have been developed in the past half-century. By the 1920s the time-consuming practice of lowering ropes over the side had been supplanted by echo-sounding devices, since refined into precision instruments that give accurate and continuous records of changing depth rather than spot records of depths at fixed stations. Some knowledge of the character of the layers of solid matter beneath the waters is gained by setting off explosives underseas and analyzing the patterns of sound waves returning from beneath the ocean floor. Motion picture cameras, lowered by cable from surface vessels, have recorded a hitherto unknown world of teeming deep sea life.[17]

Until recently direct observation of the inner depths was limited to a few feet, then to a few hundred feet beneath the surface; for deeper water studies, scientists had to rely on use of instruments. Since ancient times, man has sought some means of going below to see the underwater world with his own eyes. The earliest diving appliance, known since the time of Aristotle, had a tube for drawing air from the surface. The prototype of the modern diving suit, connected to a surface air pump, was invented in

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[16] Robert C. Cowen, *Frontiers of the Ocean* (1960), p. 37.

[17] A device containing four television cameras, linked to shore by a five-mile coaxial cable, has been installed off the California coast by the Scripps Institute of Oceanography.

1819. Navy divers today have reached a simulated depth of as much as 600 feet.

Invention of the SCUBA (self-contained underwater breathing appliance) 20 years ago freed the diver from the cumbersome suit, the metal helmet, and the cable attached to a surface vessel. Skindiving, in which the swimmer is equipped only with a mask, connected by a tube to a tank of compressed air (aqualung) on the back, and with flippers on the feet for speed, provides a much improved means of direct observation down to 100 feet below the surface.

The great barrier to direct observation at great depths is water pressure, which increases nearly a half-pound per square inch for every foot of depth. Under heavy pressure, the nitrogen of the air breathed in by the diver dissolves in his blood and tissues; if he returns to the lower-pressure atmosphere too quickly, the nitrogen is released explosively, like carbon dioxide in soda water when a bottle cap is removed. This causes "gaseous embolism," paralysis, and sometimes death.[18]

DEVELOPMENT OF BATHYSPHERE AND BATHYSCAPHE

The NASCO report commented on the scientist's need "to see, touch, taste, smell and hear the universe . . . to go down to the sea floor, walk around, observe and collect specimens and see to what extent the environment on or near the bottom of the sea is like that on the surface of the land." The first device built for deep sea observation was the bathysphere, invented by William Beebe and Otis Barton and first tested in 1930. The bathysphere was like an enlarged diving suit with space for two persons—a steel-enclosed sphere with portholes of fused quartz which was lowered and raised by steel cables from a surface ship. Beebe and his associates made a number of descents, the final one in 1948 taking the sphere to a record depth of 748 fathoms (4,488 feet).

The bathysphere was supplanted shortly after World War II by the bathyscaphe, designed by the Swiss scientist-engineer Auguste Piccard on the same principle that he

[18] Even submarines, whose thick hulls are constructed to withstand heavy water pressure, are limited to the upper layers of ocean water. The Navy does not disclose the working depth of combat submarines, but the nuclear-powered Nautilus was reported by Jane's *Fighting Ships of the World* for 1957-58 to have an operating depth limit of 700 feet.—Report of House Committee on Science and Astronautics, *Ocean Sciences and National Security* (July 1, 1960), p. 31.

had used in designing a stratospheric balloon. Piccard conceived the idea of attaching a cabin with pressure-resistant hull to a lighter-than-water float, which would sink to the bottom when weighted and rise when ballast was cast off. By thus freeing the sphere from cable attachment to a surface ship, the ever-present danger that the cable, buffeted by currents, would snap and leave the container stranded at the bottom was eliminated.

Piccard's first bathyscaphe, $FNRS_2$,[19] was converted after a number of experimental dives into an improved model, now owned by the French Navy. His third bathyscaphe, the *Trieste*, incorporating further improvements, was tested in 1957 in the Mediterranean by the U.S. Navy, which then purchased it for oceanographic research. The *Trieste* has since made dozens of dives, reaching a record depth on Jan. 23, 1960, of 35,800 feet—nearly seven miles—at the bottom of the Challenger Deep in the Mariana Trench off Guam. According to Andreas B. Rechnitzer, scientist in charge of the Navy's bathyscaphe program, the *Trieste* has yielded "scientific and technical information of major importance to future manned exploration of the oceans." [20]

Occupants of the *Trieste* on its seven-mile dive saw flatfish and shrimp swimming at great depths or squirming in the bottom sediment, clear evidence of currents that bring oxygenated water down from near the surface. The bathyscaphe has proved invaluable for testing new submarine instruments — water current meters, electronic depth gauges, temperature sensing devices, etc.—for their capabilities under extreme pressure. Better hull fittings for submarines are being developed as a result of such tests.

The *Trieste* is considered a "model T" to be greatly improved in the future; French and Russian bathyscaphes under development are expected to surpass it. An improved bathyscaphe could be driven vertically through deep waters or remain for long periods at fixed stations; use of lighter materials for the structure would permit carrying more equipment and more powerful motors. Piccard has envisioned a bathyscaphe cabin made entirely of plexiglass, which would not only reduce the weight but also give an unobstructed view of the depths.

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[19] Named after Fonds National Belge de la Recherche Scientifique, Belgian research agency which supported Piccard's work. The first FNRS was his stratospheric balloon.

[20] Testimony, House Committee on Science and Astronautics, April 28, 1960.

Devices for exploring the mid-ocean, an area even less well known than the bottom, would present less of a technical problem. A new type of submarine under construction for the Navy, made of high-strength aluminum alloys and known as the "aluminaut," promises a research vessel capable of cruising at 15,000 feet below the surface. The Navy already owns a small bathyscaphe for shallower explorations than those made by the *Trieste*. Jacques-Yves Cousteau, co-inventor of the aqualung and commander of the French research ship *Calypso*, has developed a "diving saucer," a water jet-propelled steel case in which a pilot and observer, lying prone, can observe and photograph the ocean depths down to 1,500 feet. The saucer was designed for surveying the Mediterranean to locate a route for a natural gas pipeline between Africa and Europe.

Present Wide-Ranging Oceanographic Projects

Oceanographic research has moved ahead rapidly in the past few years, owing in part to stimulus from activities of the International Geophysical Year of 1957-58. Much of the work has been carried on in cooperation with other countries. International cooperation is essential in various kinds of marine research because the high seas are common property and also because the very magnitude of the job demands a sharing of effort.

A prime objective of current expeditions is to carry out ocean-wide surveys that will provide for mariners of the future a three-dimensional map of the oceans as detailed and accurate as the land maps of today. The oceanic maps of the future will indicate the varying depths, bottom topography, paths and speed of currents at all levels; the temperature, acoustical and magnetic properties, oxygen content, salinity, density of the various areas of the sea; the types, concentrations, habits and mobility of sea life; and other details for which all the basic information is not yet available.

Much new information of this kind has been obtained in the past few years. Undersea explorers have found numerous humps, ridges, mountain peaks, lagoons, mid-ocean rivers and other phenomena. Submarine surveys of the Arctic Ocean have shown it to have a fantastically rugged floor, featuring parallel mountain ranges that divide the ocean into two basins. Flights carried out over the area within the past few weeks by U.S. Navy planes equipped

with magnetic mapping devices have led to discovery of a third drowned range close to the two previously found.

Oceanographic research ships have established existence of a great mountain range extending 40,000 miles through all the main oceans except the North Pacific. Coast and Geodetic Survey ships last year discovered the 20th seamount in a 600-mile chain stretching across the Gulf of Alaska. And Columbia University's research ship *Vema* discovered a 16,000-foot mountain whose highest knob reached to 120 feet beneath the surface.

The Coast Guard announced in April that it was initiating a study of three million square miles of ocean between the Hawaiian Islands and Alaska—the first attempt by the American government to survey a wide ocean area "with systematic, closely spaced observations encompassing nearly all aspects of oceanography." The United States is one of a dozen countries participating in a long-range project for intensive exploration of the Indian Ocean.[21] The project aims not only to supply basic data on one of the least known oceans but also to point the way to developing new food sources for the densely populated areas of the Far East.

An important step for advancement of oceanography was taken early this year when a National Oceanographic Data Center was established in Washington, D. C. The center will process the accumulating mass of oceanographic data now scattered among dozens of government agencies and private institutions. Negotiations for data exchanges with other countries have already been opened. Assistant Secretary of the Navy James H. Wakelin reported last winter that the data in hand includes approximately two million machine-punched cards covering information gathered during the past decade by the Navy's Hydrographic Office, "about three million current observations, about 600,000 bathythermograms, several millions of wave and sea surface temperature observations, and much more data in various stages of processing." [22] For the next few years the center will concentrate on processing data from the North Pacific and Indian oceans.

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[21] The other countries are Australia, Ceylon, France, Germany, India, Indonesia, Japan, Pakistan, Union of South Africa, U.S.S.R., United Kingdom. The project is sponsored by the Special Committee on Oceanic Research of the International Council of Scientific Unions and the United Nations Educational, Scientific and Cultural Organization.

[22] Address at dedication of the new center, Jan. 16, 1961.

Expansion of Oceanographic Research

CONSIDERING the magnitude and importance of the task, this country's present effort in basic oceanographic research appears minor. The United States has about 70 oceanographic laboratories, twice as many as 15 years ago, but many of them are small, some are concerned only with local fishery problems, and others are attached to universities with limited curricula in oceanic sciences.[23]

Only a few of the 30 laboratories connected with educational institutions have funds to sponsor seagoing expeditions. Most of those which undertake such expeditions are financially dependent on contracts from the government for projects of a practical nature, which may prevent them from pursuing long-term basic research programs that yield no immediate economic return. Representatives of non-governmental oceanographic centers told the Senate Commerce Committee last March that their laboratories lived a hand-to-mouth existence on the proceeds of short-term contracts.

Curbs on Quick Expansion of American Research

Oceanographic research is a multi-science undertaking requiring the services of biologists, chemists, geologists, meteorologists and physicists, all of whom are in great demand in other areas of research. The National Academy of Sciences committee found that in 1958 only 1,548 scientists were engaged in oceanographic work and that only 560 of them were at the senior project level.[24] Only 12 universities offered oceanographic courses leading to a Ph.D. degree and all branches of oceanography were covered in only four universities. Almost certainly no more than 20 Ph.D.'s in oceanography are graduated per year.

Assistant Navy Secretary Wakelin, testifying on May 17, 1960, before the House Merchant Marine Subcommittee on Oceanography, described the shortage of scientific personnel as "the most critical element in expanding our efforts." However, an encouraging rise of interest in oceanography among students has occurred in the past few years. Wake-

[23] Twenty-five of the 70 laboratories are operated by the federal government.

[24] The number of professional oceanographers in the U.S.S.R. has been estimated at 800-900. Intensive efforts to swell the ranks of trained Soviet oceanographic personnel are said to be in progress.

lin said a survey of 10 educational institutions showed that the number of graduate students of oceanography had grown from 137 in 1958 to 246 in 1960.

Many prospective students of oceanography are unable to enroll because of lack of facilities. A University of Miami oceanographer told the Senate Commerce Committee on March 16 that the number of students seeking admission to graduate work in marine sciences at that institution had risen every year, from 40 in 1953 to 389 in 1960, but the number had to be kept down to about 50 a year because of insufficiency of faculty, equipment, classroom and laboratory space. Woods Hole Oceanographic Institution receives three to four times as many applicants as it can accommodate on ships and at shore facilities.

Dearth of ships is a major deterrent to expansion of oceanographic research. About 70 vessels are assigned to oceanographic work, but most of them are small and old.[25] The greater number are converted fishing vessels or yachts; some are tugs, barges or patrol vessels. Only six of the 15 civilian institutions which do contract research for the Navy have ships which operate in the open sea. The Navy Hydrographic Office has 15 research ships, nearly all converted from other uses; the Coast Guard has one; the Coast and Geodetic Survey operates five oceangoing ships.

Extent of the Soviet Activities in Oceanography

Much of the present impetus for expansion of oceanic research has come from reports of intensive Soviet effort in this field. A report submitted to the House Science and Astronautics Committee last year by Assistant Navy Secretary Wakelin dated the beginning of Soviet expansion in 1955. Since that time, "The U.S.S.R. has displayed a large, modern research fleet second to none, has announced the construction of new research facilities, has operated its research fleet throughout the oceans of the world, and has organized a sizable manpower force to conduct oceanographic research."

The Senate Commerce Committee report of June 20 on the bill now pending in the Senate said: "Soviet Russia ... is operating more research ships than the entire free world

[25] The Senate Commerce Committee report of June 20 on the bill now pending in the Senate gave the average age of the U.S. oceanographic fleet as 19 years; four ships are more than 30 years old and one was built in 1923.

and is operating them in all oceans. Moreover, the Soviet scientific ships are larger, better equipped, have more laboratories, and accommodate more marine scientists than those of any other nation." While many of the Russian ships, like the American, are converted vessels, the Russians have outstripped the United States in number of new ships especially designed for oceanographic research.

Wakelin noted in his report to the Senate committee that much of the Russian research is of an applied nature, directed toward practical applications of new knowledge. Great interest is displayed in polar and deep sea explorations and in exploration of fisheries. Soviet attempts to develop northern sea routes are giving the Russians "a leading position in Arctic oceanography, . . . and the operations of the research fleet throughout the oceans of the world have shown an impressive ability to collect oceanographic data." Soviet oceanographers are doing "high quality work . . . in biology and fisheries research, marine geology and seismology, particularly in conjunction with deep sea research." Wakelin did not feel that the Soviet research effort was as "scientifically comprehensive" as that of the United States, but Soviet activities, particularly during the International Geophysical Year, "did much to increase the stature of the U.S.S.R. among the world leaders in oceanography as well as to provide scientific support for the Soviet economic and political aspirations."

Proposed Ten-Year Program for the United States

The "Marine Sciences and Research Act of 1961," introduced by Sen. Magnuson and reported by the Senate Commerce Committee, would establish a comprehensive 10-year program of oceanographic research and surveys and authorize construction of ships and shore facilities and the training of specialists. The bill is almost identical with the measure approved by the Senate last year, except that it gives more emphasis to development of oceanographic instrumentation and includes the Great Lakes in the program.

A Division of Marine Sciences, with representation from government agencies and non-governmental universities, laboratories, industries and foundations with an interest in the oceans, would be established in the National Science Foundation. The division would be authorized to develop

a continuing national policy and program for promotion of ocean studies; to recommend contracts, grants or loans for carrying out the program; to encourage cooperation among federal agencies engaged in different phases of ocean research; foster exchange of information with foreign oceanographic agencies; and evaluate research done by the government or by agencies aided by the government.

The bill outlines in some detail the areas for intensified work in study of the oceans to be undertaken by various government agencies. It would authorize the National Science Foundation itself to spend, over the 10-year period, $10 million for construction and $12 million for operation of oceanic research ships; $8 million for construction and $37 million for operation of shore facilities; and $5 million for education of senior and graduate students.

Spokesmen for most of the separate agencies affected by the measure told the Senate Commerce Committee, when the predecessor bill was pending last year, that they saw no need for special legislation; they already had authority to engage in oceanographic work and were in fact carrying out some of the recommendations made in the NASCO reports. While a need for better coordination of government activities in oceanography was recognized, it was generally felt that the existing interagency committee could effect that improvement. Some objections were raised to singling out a special area of multi-science research for separate authorizations, instead of continuing the present more flexible approach.

Alan T. Waterman, director of the National Science Foundation, cautioned against creating "too great an imbalance between oceanography and other areas of science." He questioned the wisdom of starting new programs before there was a sufficient number of trained scientists to put them into effect to best advantage. There was universal agreement, however, that more money was required to attract and train oceanographers and to build up the physical facilities needed to amass knowledge of the ocean depths.